

# Technique and Technology in the Composition *Mantra*: Some Analytical Considerations\*

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This paper relates to Stockhausen's composition method of the 1970s based on the concept called "formula". This method is in part a derivation and in part an improvement of serialism. Stockhausen applied it in his works starting from 1970, with the composition *Mantra* for two pianos and ring modulator, and refined it during his whole life. This paper will discuss the formula's concept and his application. In particular, the author tries to analyze the first composition where the formula's method is applied under two different points of view: the composition method and the rule of technology in the composition.

*Keywords:* formula, technique, technology

## Introduction

*Mantra* for two pianos, antique cymbals, wood block, and electronics, composed in 1970, marks for Stockhausen a turning point in his technique with the experimentation of the "formula". This is a method that intends, on the one hand, to provide a structural foundation to the composition and, on the other hand, to overcome some limitations that can be found, for example, in serial composition or in "moment form". *Mantra* is also an example of the application of live electronics with the use of the so-called ring modulation, controlled by the pianists themselves during the performance. Therefore, it is a very significant work within the context of Stockhausen's output and, at the same time, also a work that has always been very successful with the audience. It is, therefore, a key work, both with reference to the composition with the formula technique, and as an example of the use of the technology live. In the present lecture, the author has used the term "technique" to define all her observations regarding the composition method, and the term "technology" to define them about the use of live electronics.

## What Is the Formula

Before presenting some analytical starting points, specifically, relevant to *Mantra*, it is opportune to introduce the main concepts related to the composition method more in general. What Stockhausen called "formula" refers to a basic structure comprising the various elements of a composition: pitches, durations, dynamics, and the rests. The whole piece composed with the formula technique has to be planned starting from this structure and developed with the elements contained in it as if it were a DNA. In various articles and

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theoretical writings presenting and analysing his compositions, Stockhausen (1992) described this method in which there are some rules as precise as in mathematics or in exact sciences, but there is also the freedom to create unexpected and unforeseen events, that is, the freedom to create:

You are probably familiar with the idea of formula in mathematics or chemistry. Since the composition *Mantra* in 1970 I use the idea of formula both in sense of a mathematical formula from which a world from relationships can be deduced, as well in the sense of a “magic formula” with which it is possible to evoke marvellous events”. (p. 2)

It is, therefore, evident that with formula is meant an organized entity that can be, in part, considered an extension of other structural nuclei used in the 20th century’s musical composition, for example, of the series, yet it is conceived with more freedom. Also it takes into consideration the various sound parameters, besides pitches only. In composition with the use of the formula, there are no special restrictions and the only basic rules to be taken into account are those for its initial organization.

The principles to compose an interesting formula are summarized by Stockhausen in the quoted writing, *The art to listen*, in which he started from the analysis of *In Freundschaft*, a piece of 1977 for clarinet. Based on the composer’s indications, we can identify the criteria to create a formula suitable to develop a musically varied and interesting work, see Table 1.

Table 1

*Indications to Compose a Good “Formula”*

No.	Rule
1	The formula is composed of groups of sounds and rests of different durations.
2	The number of groups of sounds and of rests needs to be balanced.
3	The foundation of the groups can be a numerical progression. Within each group there must be the same type of balance between sounds and rests as in the overall formula.
4	The groups of sounds within the formula, has to be built with variety and using as many intervals as possible. It should have a melodic profile and a cyclical course. There may be repetitions of the same sound.
5	In each formula’s element, pitches have to vary in number.
6	Within each group there should be a relation between durations and repetitions should be avoided.
7	Short durations should preferably be placed at the beginning of a group.
8	Each group within the formula has to be dynamically differentiated.
9	Before and after the rests, dynamics should change.
10	For each pitch it is opportune to choose different durations.

By observing the original formula of *In Freundschaft* (see Example (1)), we can point out its characteristics and verify the general principles schematized in Table 2: (1) the formula is composed of several elements- here there are five- separated by rests; (2) Each element is characterized differently from the others; and (3) pitches, intervals, dynamics, and rhythms vary as much as possible.

Example (1) Original formula of *In Freundschaft*

Formula of IN FRIENDSHIP

The image shows a musical score for a formula titled "Formula of IN FRIENDSHIP". It consists of two staves. The top staff is a single melodic line with various rhythmic values and dynamics. Above the staff, there are numerical groupings: 1, 4, 2, 7, 3(-f), 2, 5, 11, and 8(+f). The bottom staff shows a more complex rhythmic pattern with many notes and rests. Circled numbers 1 through 5 are placed above the top staff, and lines connect them to corresponding circled numbers 1 through 5 on the bottom staff, indicating the structure of the formula. The notation includes various musical symbols such as accents, slurs, and dynamic markings like *ff* and *f*.



Table 3

*Summarizing Table of Mantra's Formula Characters*

Element	Number of sounds	Sound's durations	Rest's duration
1	4	10/4	6/4
2	2	6/4	2/4
3	4	15/4	1/4
4	3	12/4	4/4

In *Mantra*, we have four elements, separated by rests of different duration. Each element is composed of a different number of sounds, each one having its own characters. All together, the sounds are 13. The upper and lower line are specular: for example, the first element of the upper line is specular to the second of the lower line, the first element of the lower line is specular to the second of the upper line and so on. Stockhausen often marked all these characters with different colors.

Once the basic structure is organized, the work develops through various techniques, principally, transposition and expansion, and also different ways of elaborating the individual sounds and their distinctive characters. It is important to derive all the development of the work from the formula:

The work arises entirely from 13-note formula, the *mantra*... That is, in each of the 13 large cycles—in each of which a note of the *mantra* is itself the central note around which the expanded forms arise—a different one of the 13 mantric characteristics predominates<sup>1</sup>.

A key aspect of the composition development is, therefore, the elaboration of the 13 sound's characters. Each of them, as we have seen, is central for each cycle of the composition itself. From here, the further expansion of the original formula's different groups begins.

We can see the characters of the individual sounds of the formula in Table 4.

Table 4

*Character of Each Sound of the Mantra's Formula*

Sound number	Sound character
1	Regular repetition
2	Accent at the end of sound
3	Normal sound
4	Turn before the sound
5	Tremolo
6	Sforzato chord
7	Accent at the beginning of the sound
8	Chromatic link
9	Staccato
10	Irregular repetition
11	Trill
12	Sforzato
13	Arpeggio

In each cycle of *Mantra*, therefore, the characters of the central reference sound are elaborated, the

<sup>1</sup> Karlheinz Stockhausen, *Mantra*, presentation notes to the CD, Kuerten, Stockhausen Verlag, Kuerten, 1991.

The score and CD 16 of *Mantra* can be ordered directly at [www.stockhausen-verlag.com](http://www.stockhausen-verlag.com).

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elements of the formula expanded, repetitions and transpositions of individual elements or of significant intervals occurred, still without altering, the structure already established from the beginning the “formula” and the sounds that compose it. Stockhausen (1991) insisted very much that in *Mantra* there isn’t any form of variation:

There is nothing else than repetitions of this “mantra” and superimpositions of the same in 12 forms of expansion and 12x13 transpositions. Indeed, in each of the 13 big cycles, each sound of the *mantra* is a central sound around which the expanded form arise- a different one of the 13 mantric characteristics predominates. *MANTRA*, therefore is not a variation form. Nothing of *Mantra* is varied, not a single note is added, nothing is “accompanied”, ornamented etc. The *Mantra* always stays itself and appears twelvefold, with its 13 characteristics<sup>2</sup>.

The various expansion cycles forming *Mantra* present, besides the central reference sound and the formula’s elements, also a reference to the chromatic scales shown in the draft of Example (3). These are musical elements acting as a starting point for the expansion of the formula intervals and for the definition of the original forms upon which the 13 cycles of *Mantra* develop.

#### Example (3) Transposition scales

The function of the scales is described in detail by Hermann Conen in his book *Formel-Komposition* (2009):

The scales, whose draft Stockhausen prepares for the composition of *Mantra*, serve to create a system of progressive widening of the intervals composing the formula, upward or downward. Therefore, the original ascending intervals extend more and more upward, while the descending ones extend downward. The chromatic scales for Stockhausen’s *Mantra* are derived from the chromatic total of the 88 grand piano keys and from the formula fundamental sound, A, considered the central sound. The chromatic scales are equidistant and contain all the sound qualities of the tempered system and are repeated again after 12 sounds toward the next upper octave. For *Mantra* scales, of all the chromatic scale qualities, the equidistance is taken into consideration most often, the results should be not whole scales, but rather arpeggios of diminished or augmented chords. This way, the widening of the interval is not regular, but quite irregular. The intervals that get switched in each different scale are placed symmetrically in relation to the higher one. (pp. 57-70)

<sup>2</sup> Stockhausen. (1978). *Texte zur Musik, 1970-1977* (German version, pp. 154-156). All the scores and the books quoted in this paper and all the works of Karlheinz Stockhausen are available at the Stockhausen Foundation of Music in Kuerten, Germany ([www.stockhausen.org](http://www.stockhausen.org)).

So, at the basis of the composition *Mantra*, we have: (1) the original formula with its characteristics; (2) the 13 sounds of the formula, each becoming central in each new cycle of the composition; and (3) the chromatic transposition scales acting as the key element for the development of the individual expansions.

In his writing, introduction to *Mantra*, all these points are highlighted: rhythm, direction of the intervals movement, characteristics of the individual sounds, bipartite structure of the formula, expansions and contractions, and elaborations of sound.

**Hints for the Analysis of *Mantra*: The Original “Formula” and Theex Position**

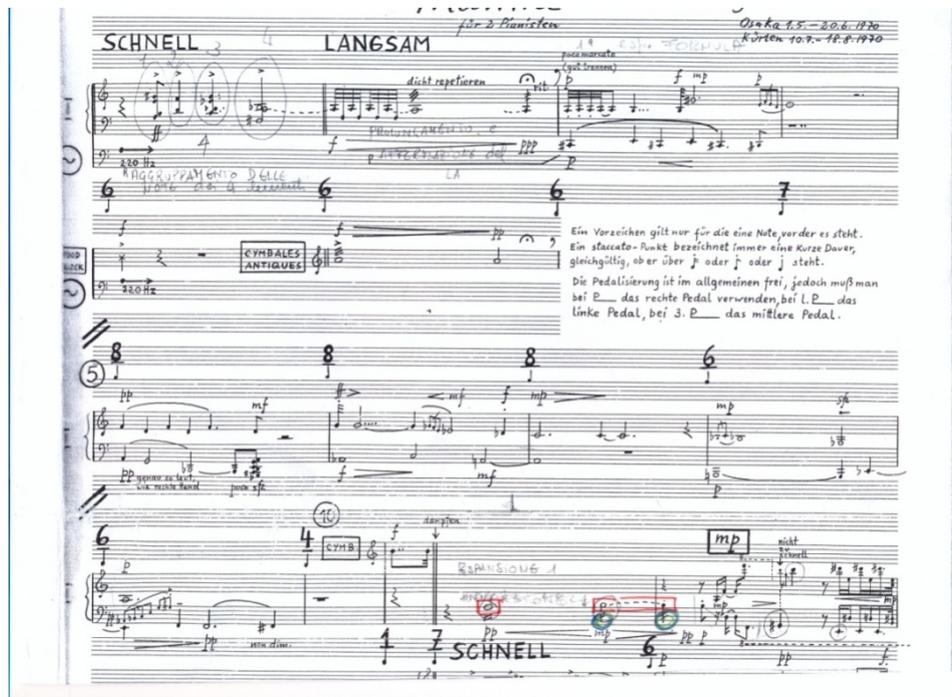
*Mantra* opens with the exposition of all the 13 sounds grouped in chords. The chords are placed, stated, and confirmed by the performance gesture, the final one is longer and preludes to a tremolo on the note A which is both the first and central sound of the *mantra* and the key sound of the first cycle of the composition (see Example (4)).

Example (4) Initial chords of *Mantra*



The sound A is emphasized by the tremolo, as well as by the pause that prolongs it and makes it resound announcing the initial exposition of the original formula assigned to piano 1, measures 3 to 10 (see Example (5)). This exposition has the function of proposing the basic structure of the work, so that the listener’s perception begins exactly from this structure. From it, the individual sounds will be later extracted in order to be proposed again and expanded.

Example (5) Initial chords and exposition of *Mantra*



The formula, thus, condensed will appear once again at the end of the work, performed by piano 2, very fast and in a “melodic” version, therefore altering the original durations of the sounds, see Example (6):

Example (6) Last measures of the composition, resuming the formula

### Hints for the Analysis: The First Expansion of the “Formula”

At the end of the exposition, the first cycle starts, that is the first expansion that develops up to bar 60, as it appears from Table 5.

Table 5

*Diagram of the First Expansion*

Formula's element	Element 1	Element 2	Element 3	Element 4
Bar's number	10-20	21-30	31-54	55-60

The 13 cycles of *Mantra* are organized in several ways. Within each of them, the author has identified three different levels of elaboration that he has defined in the following way: Level 1, or “macro-level”, which uses the original formula's sounds with expanded values; Level 2, which emphasizes the character of the central sound of each individual expansion; and Level 3, which contains the different elements of the formula variously repeated and transposed.

In expansion 1 (see Example (7)), the macro-level is obtained by expanding the sounds of the original formula grouped in the same way in the four elements. The expansion of the first element of the formula takes place from bar 10 to bar 20 of expansion 1 and expands the first four sounds of it.

Level 2 is about the development of the dominant characters of each expansion central sound. In the case of the first expansion, the second level consists of the regular repetition of the central sound A, in the form of repeated notes and tremolo. The tremolo is a very important element used to prolong the sounds, and in the course of the whole work, it is used in several points and with different speeds.

Level 3 comprises the forms of transposition or inversion of original formula's elements. Some examples in the first expansion are: the attack of the second piano that starts in the lower line with the first element of the formula transposed. In bar 15 again the second piano plays a contraction of the third element of the formula.

In Example (7), the first part of expansion 1 is introduced, from bar 10 to bar 18. Marked in red are the original formula's sounds with their durations expanded (Level 1); marked in green is Level 2, distinctive character of the central sound of the expansion, in this case: regular repetition; marked in blue is Level 3, repeated and transposed elements of the original formula.

Example (7) Expansion 1: bars 10 to 20 with the three levels of elaboration

The image shows a handwritten musical score for 'Mantra' by Stockhausen. It features three systems of music. The first system includes piano and violin parts with markings like 'SCHNELL' and 'TREMOLI'. The second system shows further elaborations with circled numbers and additional markings. The third system is a tempo table with five levels: SEHR SCHNELL, SCHNELL, MÄSSIG SCHNELL, LANGSAM, and SEHR LANGSAM, each with a corresponding rhythmic pattern. The score is marked with 'copyright K. Stockhausen 1975' and 'Werk nr. 32'.

Within the main elaborations of the three levels identified, that is expansion of the formula's sounds, emphasizing of the central sound characters, repetitions of the elements of the formula, we also have some important transformations of the individual sounds or groups of sounds that condense in four fundamental typologies: rhythmic, melodic, timbric, and dynamic different elaborations of sounds. These kinds of elaborations are used, not only in *Mantra*, but also from now on in all Stockhausen's works composed with the technique of formula.

Table 6 is a summary of these transformations.

Table 6

*Types of Transformation of the "Formula"*

	Melodic typologies	Rhythmic typologies	Dynamic typologies	Timbric typologies
1	Continuous sound without transformation	Sound held	Sound held	Timbric variation on a continuous sound
2	Glissando upward and downward	Periodical attack + sound held	Initial accent	Change of colour at the beginning of the sound
3	Indirect attack, the main sound is started with a mordent or turn	Sound held + periodical attack	Accent at the end of the note	Change of colour at the end of the sound
4	Acciaccatura	Periodical attacks in the middle of a sound held	Accent in the middle	Change of colour in the middle of the sound
5	Portamento from above or from below	Alternation of legatos (slurred) and staccatos (detached) on a held note	Periodical oscillation	Continuous changes of colour with crescendos and decrescendos
6	Broken sound	Dotted rhythms on the same note	Ritardando	Regular changes of timbre at periodic intervals
7	Tremolo	Ritardando and accelerando on the same duration	Accelerando	Light and dark
8	Chromatic transformation or in arpeggio of the head or of the tail of a sound	Aperiodic parlato (spoken)	Oscillations with slurred note	Irregular changes
9	Trill		Nervous curves	Nervous changes

### Some Final Observations About the Technique

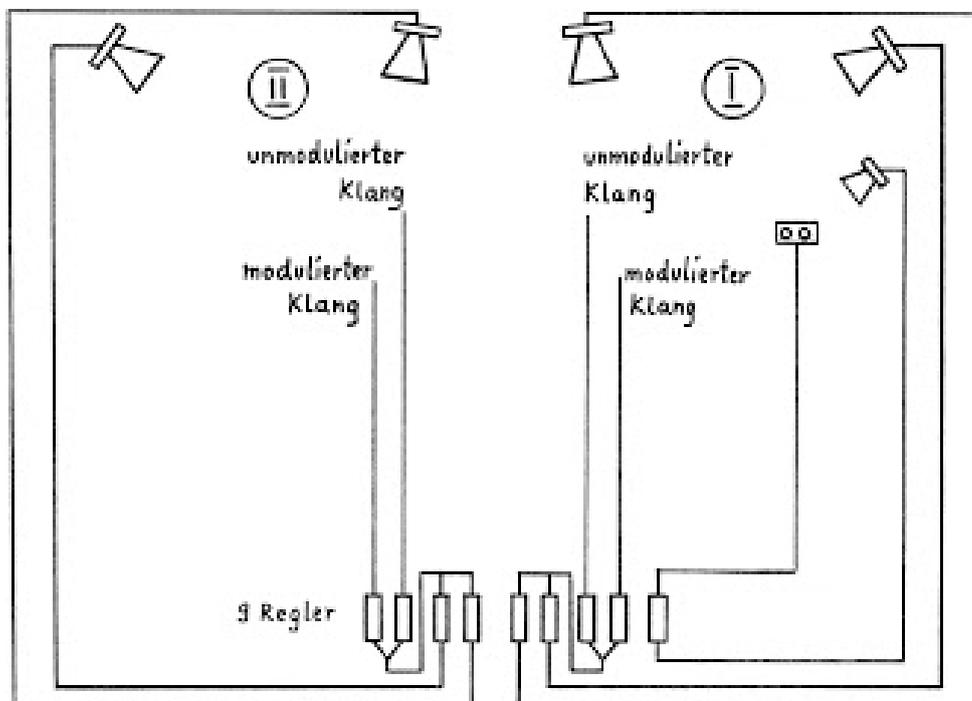
From the analytical hints offered here, that does not allow the author to examine the whole work in detail, it is already possible, however, to draw some conclusions about the formula technique that, after *Mantra*, will be used by the composer in many works of small and large size: (1) The formula is a structure with characters defined in function of the subsequent development of the piece; (2) there are rules for its composition, therefore, we can talk of method; (3) the various techniques of elaboration, with reference to pitches, are essentially related to transposition and to expansion; (4) further transformations are obtained through melodic, rhythmic, dynamical, and timbric variations; and (5) even though, there are basic rules both for the composition of the formula and for its subsequent elaboration, however, it's not a mechanical course, instead, we can find a certain freedom in the application of the basic principles of this method.

The attempt to give shape to a method derives from the need to provide an organization to the composition elements, a form of control that, nevertheless, also wants to be flexible and allows to range beyond the excessive restrictions imposed by other techniques.

### The Technology: The Function of Technology in *Mantra*

As defined above, with the term “technology”, the author has indicated the use of live electronics controlled by the pianists during the performance. The instrumentation of *Mantra* indicated in the score includes two pianos, each coupled with 12 ancient cymbals, a wood-block, a sine-wave generator, called ring modulator for its function and a loudspeaker. The plan for the disposition of the instruments is at the beginning of the score and corresponds to Example (8):

Example (8) Live schema of *Mantra*



The application of live electronics in this composition has a twofold function: (1) timbral, obtained by multiplying the piano frequencies by the waves of different frequency produced by the modulator; and (2) structural, since each cycle-expansion of *Mantra* is defined also by the change of the base frequency generated by the modulator and the frequencies generated correspond to the central sounds of the various expansions, the constituent sounds of the formula-mantra.

The timbral function of the ring modulation is accomplished by a device especially designed by Stockhausen and built for the occasion, described by the composer himself:

The so called ring modulation, which I have employed as a technical process, makes possible a new system of harmonic relationships. To this end, each of the pianists has an apparatus at his left into which a microphone amplifier, a compressor, a filter, a ring modulator a scaled sine-wave generator, and a volume control has been built. The piano sounds are amplified by 2 microphones and ring-modulated by sine-waves. Behind each piano stand loudspeakers which project the modulated sound simultaneously with the played sound. (Stockhausen, 2003, p. 7)

Therefore, the ring modulation has the timbral function of creating new harmonies, obtained by multiplying the frequencies of the piano by those of the sine-wave generator. According to the composer, the result should be a series of new harmonic relationships and which could not be obtained without the use of technology.

In 1970, when *Mantra* was composed, it was necessary to build a special device to accomplish the ring modulation wanted by Stockhausen. In the notes to the score, we can read: A special modulator, MODUL 69 B was built for *Mantra*. This piece equipment has 3 microphones inputs with regulable microphone amplifiers, compressor, filters, sine-wave generator and a particularly refined ring modulator.

If at the time *Mantra* was composed, technology was based on analogic devices often especially built for the occasion, now technological evolution has brought about a deep transformation that, however, in many cases, has not altered the deep nature of some works; it simply takes the place of the previous one realizing the same instruments in a different way. The ring modulator for example, like, on the other hand, most electroacoustic devices of the past, are currently realized with digital technology and, therefore, consist basically of algorithms simulating those devices.

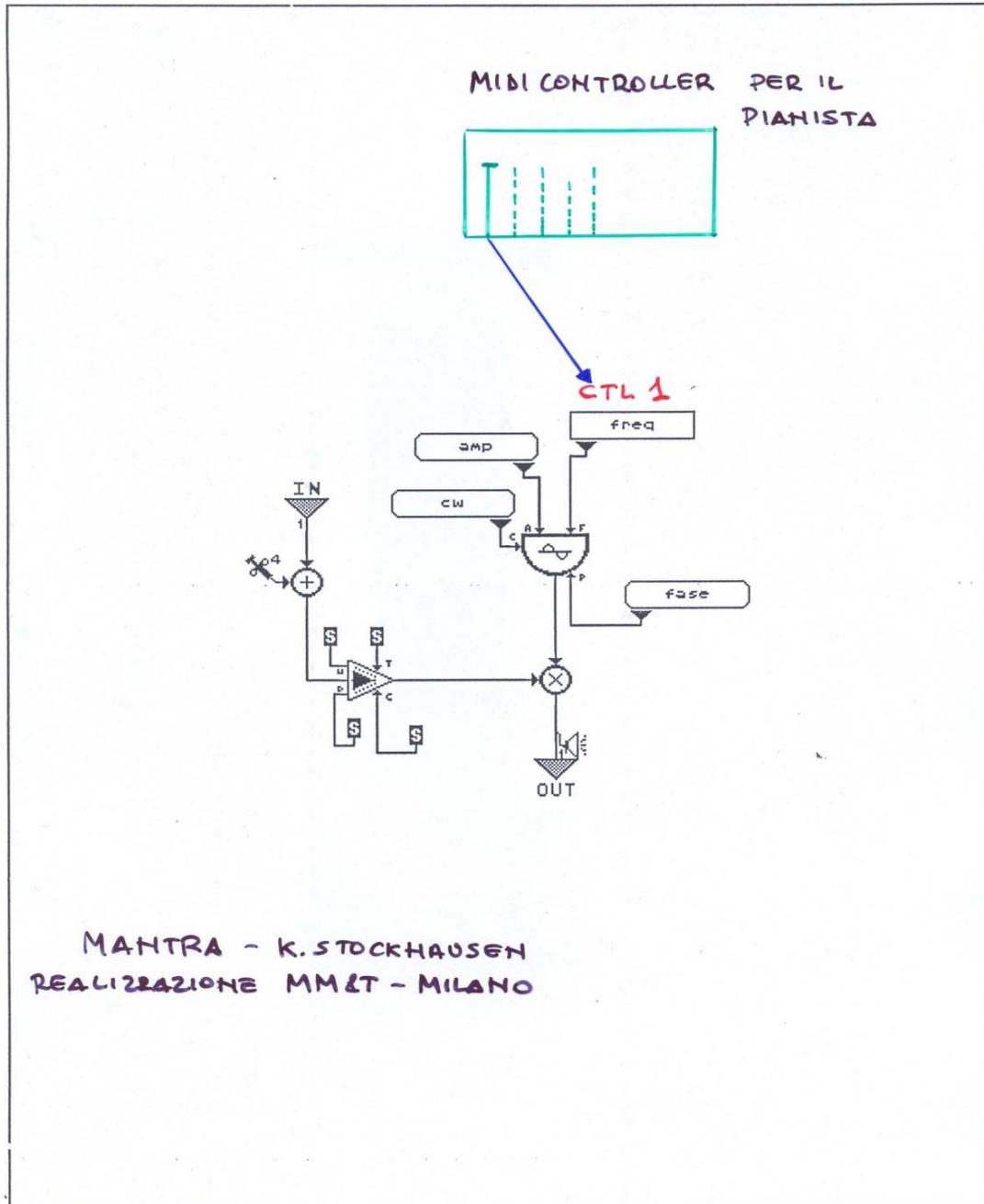
Different performances of work *Mantra* are by now realised with various examples of digital implementations. At the Studio MM&T in Milan, for example, in 1994 the ring modulator was realized through the software of the MARS (Musical Audio Research Station) workstation, a digital device prepared by the engineer Giuseppe Di Giugno to realize algorithms for live performance and synthetic algorithms for the creation of virtual instruments. In the figure of Example (9), it is possible to see the algorithm of the virtual modulator realized through this experimental workstation. The author described this performance experience in an article where she showed the capability of recreating historic electro-acoustic compositions with new technological supports (Sargenti, 1995).

Example (9) Algorithm of the ring modulator realized through MARS



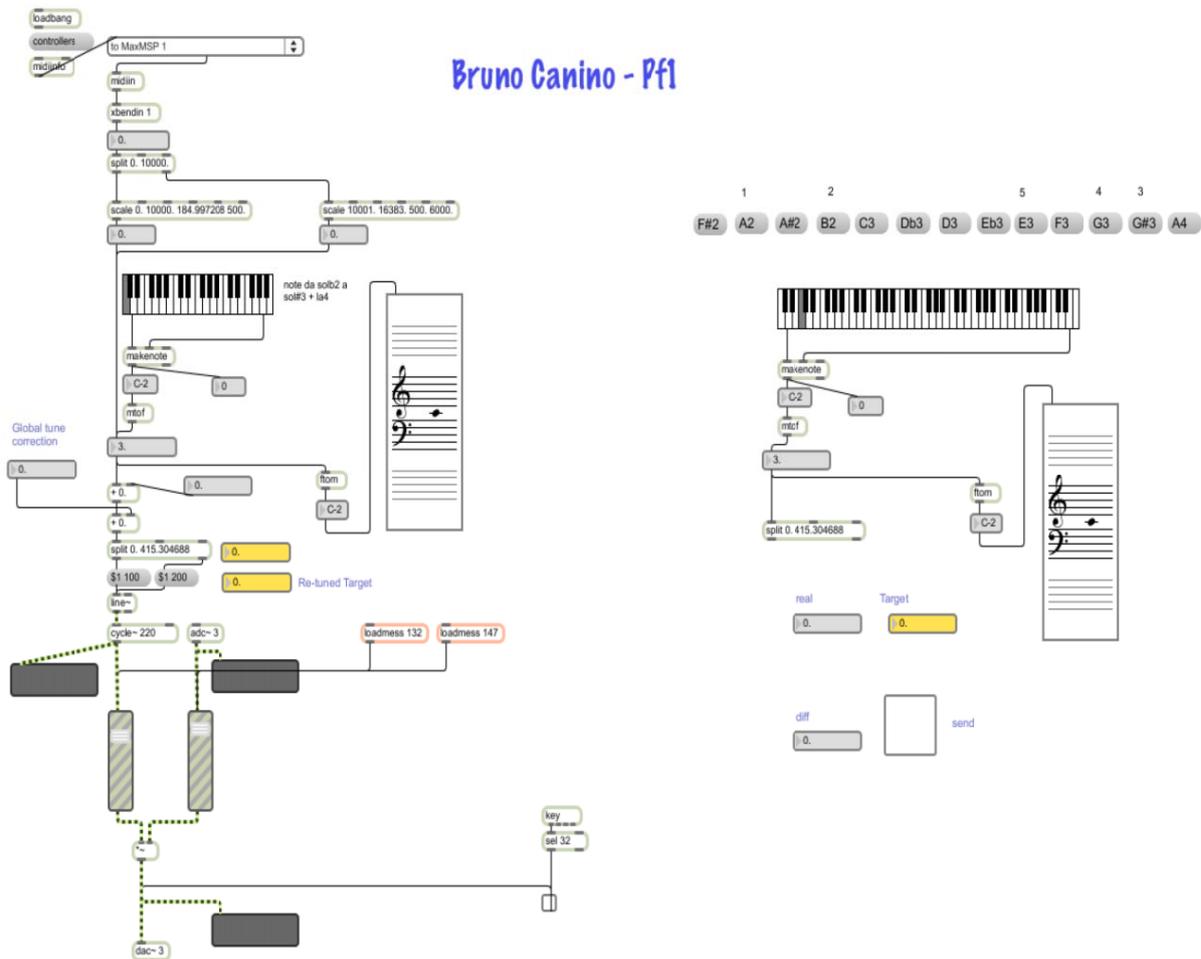
MANTRA1

EDIT20



Technological evolution has progressed further and currently enables us to realize algorithms for the performance of works, such as *Mantra* in even simpler and improved ways, like, for example, the algorithms realized through the MAX/MSP software (see Example (10)).

Example (10) Algorithm realized through the MAX/MSP software by Studio MM&T, for the performance of *Mantra* at Festival MITO, Milan on 20 September 2011.



Therefore, the technology used for the performance of *Mantra* has evolved further. In its essence, the basic idea proposed by Stockhausen does not suffer ageing. He was a pioneer in electro-acoustic research applied to composition and the fundamental principles of his creations are often still topical. An interesting aspect that still today is an element of topicality of some works of the 1970s is exactly the fact that the musical idea is not hindered by the change of the instruments necessary to realize it and with present technologies; if the performance procedures are simplified, the thought below the work remains unchanged anyway.

Therefore, electronics in *Mantra* definitely has a dominant timbral function. The structural function of technology in this work is not secondary. Each expansion cycle is based, as we already noticed, on one of the 13 pitches of the formula which becomes the central pitch of the whole expansion. Each of the expansions has a relation with a change in the frequency produced by the sine-wave generator, therefore, the ring modulation changes in each cycle of the whole work. From Table 7 and Example (11), we can see where in the score we have the change of frequencies produced by sine-wave generator (Table 7) and the value to be set on the modulator in relation to the points in the score where the changes occur. In Example (11), we have the

representation in musical notation of the same frequencies.

Table 7

*Changes of Frequencies in Hertz Values and in Musical Pitches*

FREQ	Piano1, bar number	Piano 1, value of frequencies	of Piano2, bar number	Piano 2, value of frequencies in hertz
0	0	220	0	220
1	64	233	64	196
2	92	415	65	117
3	110	330	97	147
4	188	349	151	139
5	202	294	176	165
6	284	923	186	124
7	438	311	448	156
8	448	277	492	175
9	527	262	536	185
10	577	233	580	208
11	608	185	610	169
12	639	220	654	262
13	687	220	687	220

Example (11)

Example (11) displays two piano parts, I and II, over 13 bars. Each part starts with a 220 Hz frequency. The notes in both parts correspond to the 13 frequencies listed in Table 7. Part I shows a sequence of notes: G4 (220 Hz), A4 (233 Hz), B4 (247 Hz), C5 (262 Hz), D5 (277 Hz), E5 (294 Hz), F5 (311 Hz), G5 (330 Hz), A5 (349 Hz), B5 (369 Hz), C6 (392 Hz), D6 (415 Hz), E6 (438 Hz). Part II shows a sequence of notes: G4 (220 Hz), F4 (196 Hz), E4 (175 Hz), D4 (156 Hz), C4 (147 Hz), B3 (139 Hz), A3 (130 Hz), G3 (124 Hz), F3 (117 Hz), E3 (110 Hz), D3 (104 Hz), C3 (97 Hz), B2 (92 Hz).

The 13 frequencies are indicated in the score both in the first and in the second piano and correspond in music notation to the 13 sounds of the *Mantra*.

Since to each expansion episode corresponds a different intonation of the modulator, the function of technology is also that of defining, through a change of harmonic relations, the episodes of the piece, therefore, it is a structural function.

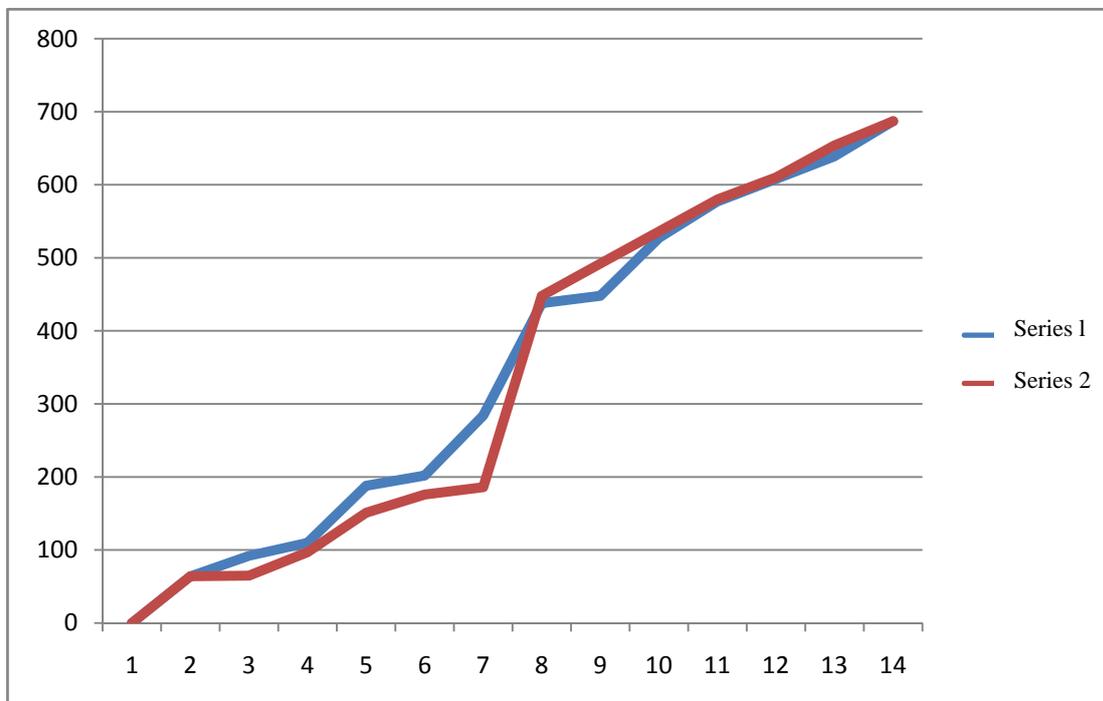
At the same time, though, such changes of frequency not always occur mechanically and simultaneously.

Going back to the definition of formula that Stockhausen himself provided, the author mention again the, so to speak, “scientific” character that defines precise rules, but also the “magical” one that enables to create unexpected events through rules. With this regard, the structural function of the modulator frequencies in *Mantra*, needs to be further analyzed. Indeed, if we pay attention to the change points of the frequencies generated by the electronics in relation to the episodes of the two pianos we can see: (1) The frequencies not always get changed simultaneously in pianos 1 and 2; and (2) there are digressions between one piano and the other one and, therefore, a variety is created, since the frequency changes and the correspondence of the expansion episodes between the two performers is not schematic.

Therefore, the application of structural changes is varied and does not reflect a pattern in a totally rigid way.

From Example (12), it is possible to understand what said: In the graphic, the course of frequency changes of piano 1 are marked in blue (values on the left side, Series 1) and those of piano 2 are marked in red (values on the right side, Series 2). On the horizontal axis are marked the 13 section of the composition (the sequence of the 13 repetitions and expansions). On the vertical axis is marked the development in the time of different values of the frequencies from the beginning to the end of the composition. As it can be seen, the frequencies at the beginning of the piece are the same for the two performers but the changes are more and more diversified during the central development of the work, to rejoin at the end.

Example (12) Graphic of the modulator frequency changes in the two pianos during the 13 parts of the composition.



### Conclusions

So, with *Mantra*, Stockhausen started a new compositional journey, applying criteria that assured an internal logic yet without getting to a complete limitation of creative freedom. After the experiences with the twelve-tone series and the compositions realized using the so called “Momentform”, Stockhausen with the “Formula” created a new composition method.

From this time on, the “formula” technique will be used by him in many important works including the cycle *Licht*, based exactly on a macro-formula from which all the works of the whole cycle are generated.

As to technology applied to this composition, it definitely has a very important timbrical function which forms a fundamental part of it and, in the composer’s intentions, wants to be the proposal of new harmonic relations. However, as it often happens in Stockhausen’s works, it also takes the structural role of formal definition of the work.

Perhaps *Mantra* can be defined one of Stockhausen’s most successful compositions. Indeed, it stands the test of time, thanks both to this application of the compositional techniques and to the real possibility of updating the technologies used for its performance. The impression one can draw by listening to it is that of a work rich in interesting ideas and timbrically varied. In particular, the several subsequent repetitions and organizations of the 13 cycles reveal, when being listened, the variety and the creative freedom within a consistent pattern. Maybe for these reasons *Mantra* remains, among Stockhausen’s works, one of the most appreciated by the audience and loved, even with its difficulty, by performers too. The author would like to conclude this lecture with the words of pianist Antonio Ballista from an interview of 2010 who, in duo with Bruno Canino, had many opportunities to perform *Mantra*: “The composition *Mantra* is one of Stockhausen’s best creations, for its aesthetic consistency, for the interest and variety of pianistic technique, for the balance between the use of technology and art, undoubtedly, a masterpiece” (personal communication, June 10, 2011).

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